CLAIMS

What is claimed is:

1. A method of forming a lithium ion battery having reduced flammability, said method comprising the steps of:

assembling a battery skeleton comprising a carbon anode electrode, a cathode electrode, a separator and packaging for said battery;

forming a solid electrolyte interphase on said carbon anode using a first electrolyte;

combining a lithium metal salt and an organic solvent and mixing with said combination an organic cation salt to form an organic cation salt electrolyte, wherein said cation in said salt is selected from the group consisting of:

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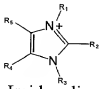
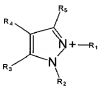

Imidazolium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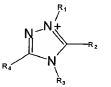
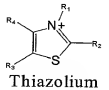

1,2,4-Triazolium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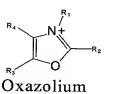
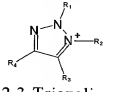
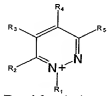

Oxazolium


1,2,3-Triazolium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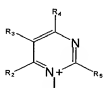
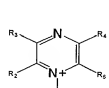
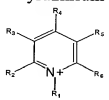

Pyrimidinium


Pyrazinium


Ammonium


Phosphonium


Pyridinium

wherein R_1, R_2, R_3, R_4, R_5, and R_6 are either H; or F; or separate alkyl groups of from 1 to 15 carbon atoms, respectively; or two of said separate alkyl groups are joined together to constitute a unitary alkylene radical of from 2 to 6 carbon atoms forming a ring structure converging on N; or separate phenyl groups, and

wherein said alkyl groups, said unitary alkylene radical or said phenyl groups are optionally substituted;

replacing said first electrolyte with said organic cation salt electrolyte; and

sealing said battery.

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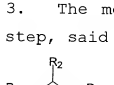
2. A lithium ion battery made by the method of claim 1.

3. The method of claim 1, wherein, in said combining step, said cation in said organic cation salt is



wherein R_4 and R_5 are not equal to H.

4. The method of claim 1, wherein, in said combining step, said organic cation salt is added at a concentration of greater than 0.5 M.

5. The method of claim 1, wherein, in said combining step, said organic cation salt is added at a concentration of greater than 1 M.

6. The method of claim 1, wherein, in said combining step, said organic solvent is selected from the group consisting of organic carbonates, gamma-butyrolactone, methyl acetate, ethyl acetate, methyl formate, sulfolane, methylsulfolane, diethyl ether, methyl ethyl ether, tetrahydrofuran, 2-methyltetrahydrofuran, 1,3-dioxolane, nitromethane, acetonitrile, dimethylformamide, dimethylacetamide, dimethylsulfoxide, benzonitrile and combinations thereof.

7. The method of claim 1, wherein, in said combining step, said carbonate solvent is selected from the group

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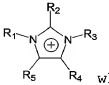
consisting of ethylene carbonate, propylene carbonate, butylene carbonate, dimethyl carbonate, diethyl carbonate, ethyl methyl carbonate, ethyl propyl catbonate, propyl methyl carbonate, butyl methyl carbonate, vinylene carbonate and combinations thereof.

8. The method of claim 1, further comprising the step of increasing the viscosity of said organic cation salt electrolyte in said battery with the addition of a binder.

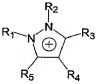
9. The method of claim 1, wherein, in said combining step, an additive selected from the group consisting of vinylene carbonate, an alkyl phosphonate and an alkyl nitrite, all at a concentration less than 0.5 M, is further included in said mixture.

10. An electrolyte having reduced flammability, said electrolyte comprising:

an organic cation salt, wherein said cation in said salt is selected from the group consisting of:



wherein R_1, R_2, R_3, R_4, and R_5 are not



equal to H, wherein R_1 and R_2 are not

equal to H, and wherein R_1, R_2, R_3, and R_4 are not equal to H;

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an organic solvent; and

a metal salt comprising an alkali or alkaline earth metal cation.

11. An electrolyte having reduced flammability, said electrolyte comprising:

an organic cation salt, wherein said cation in said salt is:

wherein R_1, R_2, R_3, and R_4 are not equal to H;

an organic solvent; and

a metal salt comprising an alkali or alkaline earth metal cation.

12. The electrolyte of claim 10 or claim 11, wherein said cation in said metal salt is selected from the group consisting of Li^+, Na^+, K^+, Mg^{++}, Ca^{++}, Al^{+++} and combinations thereof.

13. An electrochemical cell comprising

an anode;

a cathode; and

the electrolyte of claim 10 or claim 11.

14. A battery comprising the electrochemical cell of claim 13.

15. The electrolyte of claim 10 or claim 11 wherein said organic solvent is selected from the group

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consisting of organic carbonates, gamma-butyrolactone, methyl acetate, ethyl acetate, methyl formate, sulfolane, methylsulfolane, diethyl ether, methyl ethyl ether, tetrahydrofuran, 2-methyltetrahydrofuran, 1,3-dioxolane, nitromethane, acetonitrile, dimethylformamide, dimethylacetamide, dimethylsulfoxide, benzonitrile and combinations thereof.

16. The electrolyte of claim 10 or claim 11 wherein said carbonate solvent is selected from the group consisting of ethylene carbonate, propylene carbonate, butylene carbonate, dimethyl carbonate, diethyl carbonate, ethyl methyl carbonate, ethyl propyl catbonate, propyl methyl carbonate, butyl methyl carbonate, vinylene carbonate and combinations thereof.

17. An electrolyte having reduced flammability, said electrolyte comprising:

an organic cation salt at a concentration of greater than or equal to 0.75 M, wherein said cation in said salt is selected from the group consisting of:

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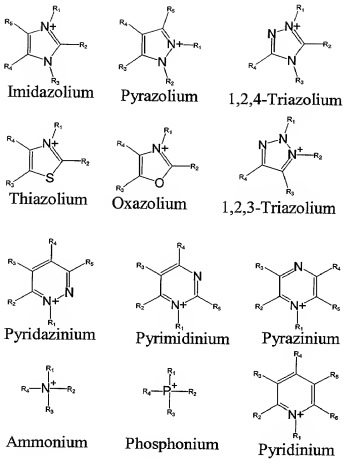

wherein R_1, R_2, R_3, R_4, R_5, and R_6 are either H; or F; or separate alkyl groups of from 1 to 15 carbon atoms, respectively; or two of said separate alkyl groups are joined together to constitute a unitary alkylene radical of from 2 to 6 carbon atoms forming a ring structure converging on N; or separate phenyl groups, and

wherein said alkyl groups, said unitary alkylene radical or said phenyl groups are optionally substituted;

an organic solvent; and

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a metal salt comprising an alkali or alkaline earth metal cation.

18. The electrolyte of claim 17 wherein said cation in said metal salt is selected from the group consisting of Li^+, Na^+, K^+, Mg^{++}, Ca^{++}, Al^{+++} and combinations thereof.

19. An electrochemical cell comprising
an anode;
a cathode; and
the electrolyte of claim 17.

20. A battery comprising the electrochemical cell of claim 19.

21. The electrolyte of claim 17, wherein said organic solvent is selected from the group consisting of organic carbonates, gamma-butyrolactone, methyl acetate, ethyl acetate, methyl formate, sulfolane, methylsulfolane, diethyl ether, methyl ethyl ether, tetrahydrofuran, 2-methyltetrahydrofuran, 1,3-dioxolane, nitromethane, acetonitrile, dimethylformamide, dimethylacetamide, dimethylsulfoxide, benzonitrile and combinations thereof.

22. The electrolyte of claim 17 wherein said carbonate solvent is selected from the group consisting of ethylene carbonate, propylene carbonate, butylene carbonate, dimethyl carbonate, diethyl carbonate, ethyl methyl carbonate, ethyl propyl catbonate, propyl methyl

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carbonate, butyl methyl carbonate, vinylene carbonate and combinations thereof.

23. The electrolyte of anyone of claims 10, 11 or 17, wherein the viscosity of said electrolyte is increased with the addition of a binder.

24. The electrolyte of anyone of claims 10, 11 or 17, further comprising an additive selected from the group consisting of vinylene carbonate, an alkyl phosphonate and an alkyl nitrite, having a concentration less than 0.5 M.

25. A gel polymer electrolyte having reduced flammability, said gel polymer electrolyte comprising:

an organic cation salt, wherein said cation in said salt is selected from the group consisting of:

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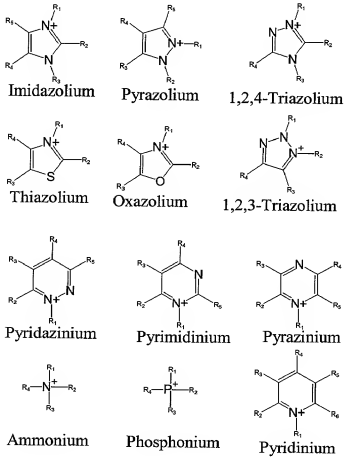

wherein R_1, R_2, R_3, R_4, R_5, and R_6 are either H; or F; or separate alkyl groups of from 1 to 15 carbon atoms, respectively; or two of said separate alkyl groups are joined together to constitute a unitary alkylene radical of from 2 to 6 carbon atoms forming a ring structure converging on N; or separate phenyl groups, and

wherein said alkyl groups, said unitary alkylene radical or said phenyl groups are optionally substituted;

an organic solvent;

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a metal salt comprising an alkali or alkaline earth metal cation; and

one or more polymers selected from the group consisting of acrylate polymer and fluoropolymer.

26. The gel polymer electrolyte of claim 25, wherein said acrylate polymer is a methacrylate polymer with at least 1 monomer copolymerizable to methylmethacrylate.

27. The gel polymer electrolyte of claim 25, wherein said one or more polymers consist of a mixture of two or more polymers.

28. The gel polymer electrolyte of claim 25, wherein said fluoropolymer is poly(vinylene)fluoride.

29. The gel polymer electrolyte of claim 26, wherein said monomer is selected from the group consisting of styrene-containing monomers, cyano-group-containing monomers, unsaturated carboxylic acids, acid anhydrides, esters, vinyl halides, vinylene halide monomers, vinyl esters, vinyl ethers and dienes.

30. The gel polymer electrolyte of claim 29, wherein said monomer is selected from the group consisting of styrene, divinylbenzene, methacrylonitrile, acrylic acid, sodium acrylate, maleic anhydride, methyl methacrylate, ethyl acrylate, propyl acrylate, tetra(ethylene glycol) diacrylate, hydroxyethyl methacrylate, vinyl chloride, vinyl fluoride, vinyl bromide, vinylene chloride, vinylene fluoride, vinylene

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bromide, vinyl formate, vinyl acetate, vinyl group-containing acids compounds or their salts, anhydrides or derivatives, methyl vinyl ether, butadiene, isoprene and chloroprene.

31. The gel polymer electrolyte of claim 25, wherein said solvent is selected from the group consisting of organic carbonates, gamma-butyrolactone, methyl acetate, ethyl acetate, methyl formate, sulfolane, methylsulfolane, diethyl ether, methyl ethyl ether, tetrahydrofuran, 2-methyltetrahydrofuran, 1,3-dioxolane, nitromethane, acetonitrile, dimethylformamide, dimethylacetamide, dimethylsulfoxide, benzonitrile and combinations thereof.

32. The gel polymer electrolyte of claim 31, wherein said organic carbonate is selected from the group consisting of ethylene carbonate, propylene carbonate, butylene carbonate, dimethyl carbonate, diethyl carbonate, ethyl methyl carbonate, ethyl propyl catbonate, propyl methyl carbonate, butyl methyl carbonate, vinylene carbonate and combinations thereof.

33. The gel polymer electrolyte of claim 25, wherein said cation in said metal salt is selected from the group consisting of Li^+, Na^+, K^+, Mg^{++}, Ca^{++}, Al^{+++} and combinations thereof.

34. The gel polymer electrolyte of claim 25, wherein said anion in said metal salt is selected from the group

consisting of I^-, Br^-, SCN^-, BF_4^-, PF_6^-, AsF_6^-, $CF_3SO_2^-$, $(CF_3SO_2)_2N^-$, $(CF_3CF_2SO_2)_2N^-$, and $(CF_3SO_2)_3C^-$.

35. The gel polymer electrolyte of claim 25 further comprising a saturated or unsaturated cyclic or acyclic organic carbonate or lactone.

36. The gel polymer electrolyte of claim 25 further comprising an additive selected from the group consisting of vinylene carbonate, an alkyl phosphonate and an alkyl nitrite, having a concentration less than 0.5 M.

37. The gel polymer electrolyte of claim 25 wherein said organic cation salt is an peralkylated imidazolium cation in combination with various anions.

38. A method for the production of a gel polymer electrolyte comprising the steps of:

combining to form a mixture an organic solvent, one or more polymers selected from the group consisting of acrylate polymers and fluoropolymers, a metal salt comprising an alkali or alkaline earth metal cation, and an organic cation salt, wherein said cation in said salt is selected from the group consisting of:

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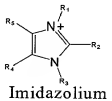
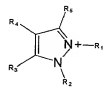
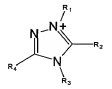
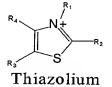

Imidazolium


Pyrazolium


1,2,4-Triazolium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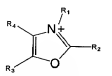
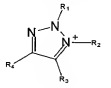
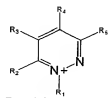
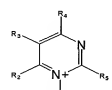
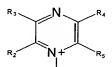

Oxazolium


1,2,3-Triazolium

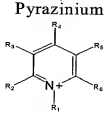

Pyridazinium


Pyrimidinium


Pyrazinium


Ammonium


Phosphonium


Pyridinium

wherein R_1, R_2, R_3, R_4, R_5, and R_6 are either H; or F; or separate alkyl groups of from 1 to 15 carbon atoms, respectively; or two of said separate alkyl groups are joined together to constitute a unitary alkylene radical of from 2 to 6 carbon atoms forming a ring structure converging on N; or separate phenyl groups, and

wherein said alkyl groups, said unitary alkylene radical or said phenyl groups are optionally substituted; and

processing said mixture.

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39. The method of claim 38, wherein said processing step is selected from the group consisting of:

a. heating said mixture at approximately 100°C to yield a homogeneous melt, followed by casting and cooling said melt,

b. exposing said mixture to UV-light initiated polymerization, said mixture also containing a photoinitiator, and

c. exposing said mixture to thermal initiated polymerization at approximately 60°C.

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